Module - 4

Associated IOT Technologies

Introduction to cloud computing

Cloud computing means storing and accessing the data and programs on remote servers that are hosted on the Internet instead of computer's hard drive or local server. Cloud computing is also referred to as Internet - based computing. cloud computing becomes as essential building block of the IOT architecture.

Cloud computing comprises a pool of multiple resources such as servers, storage and network from single / multiple organizations. These resources are allocated to the end users as per requirement on a payment basis.

In cloud computing architecture, an end user can request for customized resources such as storage space, RAM, Operating systems and other software to a cloud service provider.

For example :

A user can request for a linux operating system for running an application from a cloud service provider, another end user can request for windows 10 operating system from the same cloud service provider for executing some application.

The cloud services are accenible from anywhere and at any time by an authorized user through internet connectivity.

Cloud computing comprises a shared pool of computing resources which are accessible dynamically, ubiquitously and on-demand basis by the users.

This shared pool of resources includes networks, storage, processor and servers.

There resources are accenible by multiple users through a regular command line terminal at the same or different time instants.

* The services of cloud computing are based on the pay-per-use model.

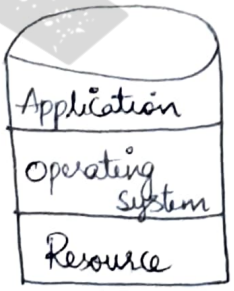
* In cloud computing, A user pays for the cloud services as per the duration of their resource usage.

Virtualization

* Virtualization is the technique of sharing a single resource among multiple end user organisations or end users.

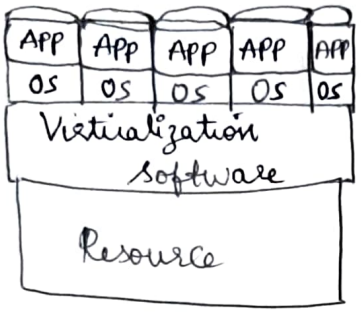
* A physical resource is logically distributed among users.

* The below figure represents a traditional desktop, where an application (App) is running on top of an OS (operating System) and resources are utilized only for that particular application.



Desktop

The below figure shows Virtualization. In this multiple resources can be used by different end users through Virtualization software.



Virtualization

* this software separates the resources logically so that there is no conflict among the users during resource utilization.

For example :

Vmware is an American cloud computing and virtualization technology company.

Vmware's desktop software runs on microsoft Windows, Linux and macOS.

Advantages of Virtualization

In IOT, data comes from different heterogeneous devices, the only concern is where to store or process the data.

The advantages of Virtualization for end users

1. Variety
2. Availability
3. Portability
4. Elasticity.

The advantages for cloud service provider are

1. Resource utilization
2. Effective Revenue generation

1. Variety :

* The process of Virtualization in cloud computing enables to use various types of applications based on the requirements of the end users.
* Various softwares can be installed over a Virtual machine for different purposes.
* for example : one can install photoeditor software, which lets you edit photos efficiently and one can also install Videoeditor, which lets you edit video efficiently.

2. Availability :

* The concept of Virtualization makes available a considerable amount of resources as per user requirements.

* Virtualization creates a logical separation of the resources.

for example :

A User uses a email service, they offer a storage capacity of 2GB, if this space is exhausted. There is a provision that if user pays some amount annually, user can get additional space to the mail service.

3. Portability :

* Portability signifies the availability of cloud computing services from anywhere in the world, at any instant of time.

for example :

A person flying from US to UK still has access to their documents. this has been made possible by platforms such as Google Drive.

4. Elasticity :

* An end user can scale-up or scale-down resource utilization as per requirements.
* Cloud computing is based on a pay-per-use model.
* The end user needs to pay the amount based on their usage.

For example :

A user rents two VMs in a cloud computing infrastructure from CSP. VM1 has the Ubuntu operating system, on which you can simulate network scenario using Network Simulator-2 (NS2) VM2 has windows 10 operating system, on which you can run a MATLAB simulation. If you release VM2 after some days, you will be billed for VM1 only. Thus user can scale-up or scale-down the resources in cloud Computing.

Advantages for Cloud Service provider

1. Resource utilization :

* the resources are distributed among different users dynamically as per their requirements.
* A particular resource provided to a user at a time instant can be provided to another user

at different time instant. Thus resource can be reutilized for multiple users.

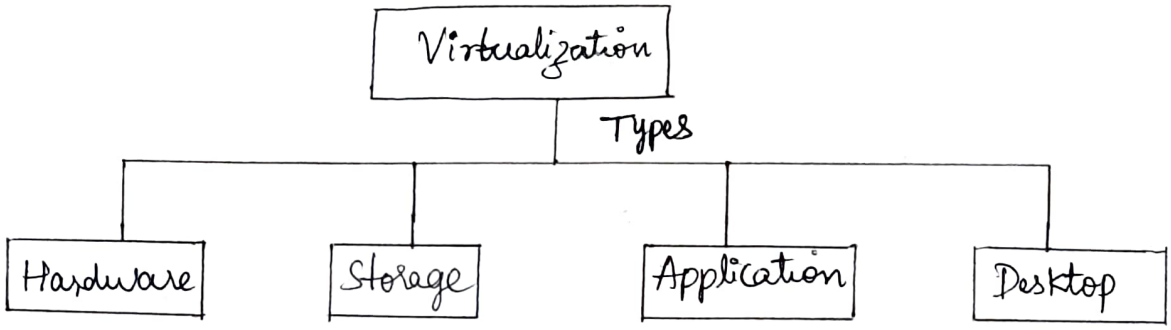
2. Effective Revenue generation

* A CSP generates revenue from the end users based on resource utilization.
* A User 'A' is utilizing storage facility from a particular CSP. The user will release the storage after a few days when the requirement is complete. The CSP earns more revenue from user 'A' for the utilization of the allocated storage facility.
* In the future, the CSP can provide the same storage facility to a different user B. hence CSP can generate revenue from user B also.

Types of Virtualization

Virtualization is categorized into 4 types based on the requirements of the users. They are :

1. Hardware Virtualization
2. Storage Virtualization
3. Application Virtualization
4. Desktop Virtualization



1. Hardware Virtualization :

this indicates the sharing of hardware resources among multiple users.

for example :

A single procesor appears as many different procesors in a cloud computing architecture. Different Operating systems can be installed in there procesors.

2. Storage Virtualization :

the storage space from different entities are accumulated Virtually and seem like a single storage location.

A user's documents or files exist in diffrent locations in a distributed fashion.

3. Application Virtualization :

A single application is stored at the cloud end. However as per requirement, A user can use the application in her local Computer without

installing that application.

4. Desktop Virtualization :

This type of Virtualization allows a user to access and utilize the services of a desktop that resides at the cloud.

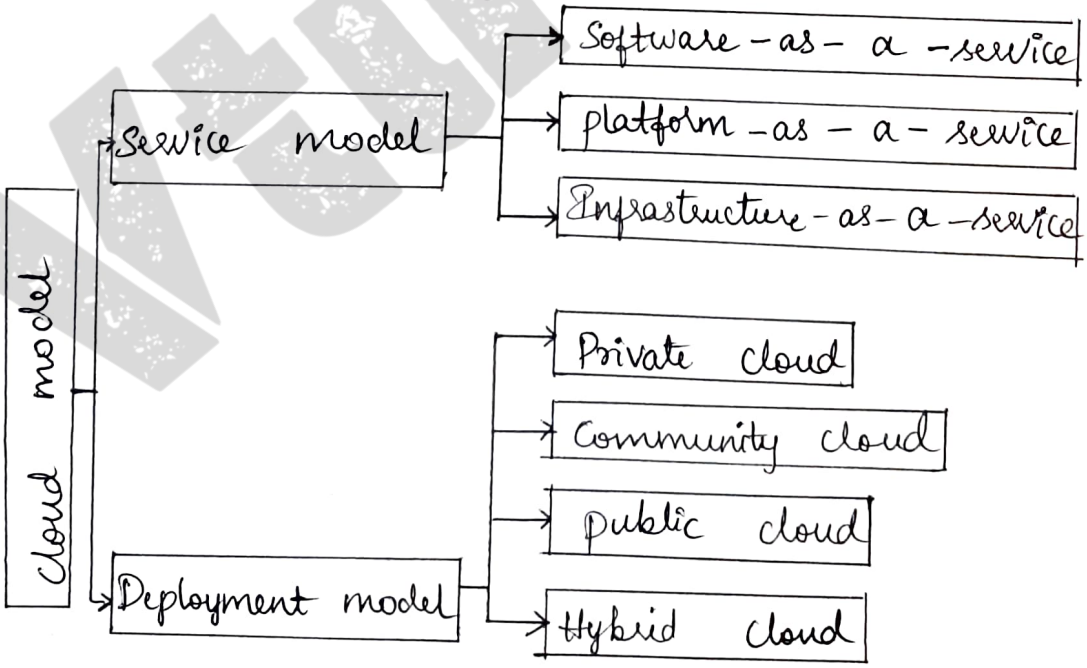
The user can use the desktop from their local desktop.

Cloud models

The cloud model is divided into two parts.

1. Service model
2. Deployment model.

As per the National Institute of Standards & Technology (NIST), it is categorized as,

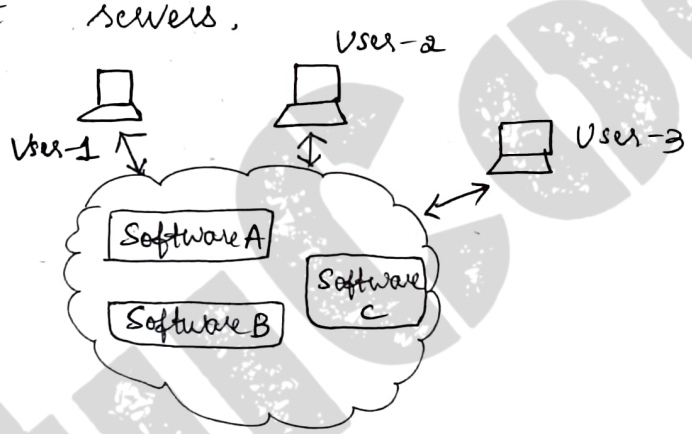


cloud model

Service model

1. Software-as-a-service (SaaS)

* this service provides access to diffrent software applications to an end user through internet connectivity.
* User need to purchase and install the software applications on local desktop
* the software is located in cloud severs.
* services are provided to multiple end users from that severs.



Advantages:

1. Scalability

Users have the provision to use multiple software applications as per their requirements.

User neednot have to worry about the update of the s/w applications.

Example

Microsoft office 365

Works on PC, iphone, Mac, ipad, Android phones & tablets.

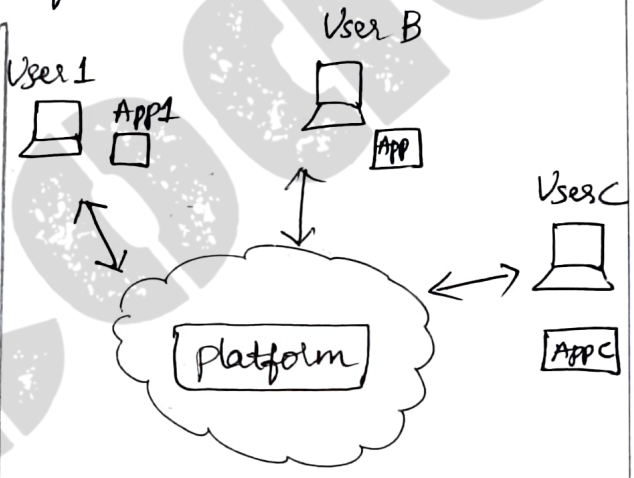
2. Platform - as - a - service (Paas)

- Paas Provides a Computing platform, by which a user can develop and run different applications.
- The cloud user need not go through the burden of installing and managing the operating system, storage and network.
- The user can develop and manage the applications that are running on top of it.

Example :

Google App Engine

Google announced App Engine in 2008, It is a platform for developing and hosting web applications in google-managed data centers. This is the first cloud computing service from the company.



3. Infrastructure - as - as - service (Iaas)

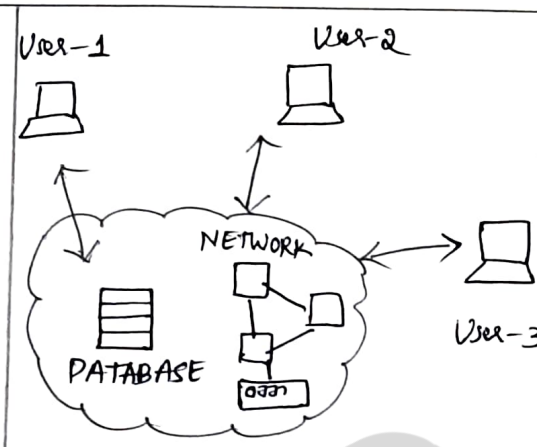
- Iaas provides infrastructure such as storage, networks and computing resources.
- A user uses the infrastructure without purchasing the software and other network components.

for example :

Google Compute Engine

This is the Iaas Component of Google cloud platform, this runs google's search engine, Gmail, Youtube.

This also enables users to launch virtual machines.



Deployment model

1. private cloud :

This type of cloud is owned explicitly by an end user organization. The internal resources of the organisation maintain the private cloud.

2. Community cloud :

This type of cloud is formed with the collaboration of a set of organizations for a specific community.

This is because, each organization has some shared interests.

3. Public cloud :

The Public cloud is owned by a third party organization. This Provides sevices to the

Common public.

The service of this cloud is available for any user, on a payment basis.

4. Hybrid cloud :

This type of cloud comprises two or more clouds (private, public or community).

Service - Level Agreement in cloud Computing

* SLA is an agreement made between cloud service provider and customer. about the services.
* SLA provides a detailed description of the services to the customer.
* this is important as customer will be aware of each and every terms and conditions of the services before availing them.
* Cloud computing architecture provides optimal and efficient services to the end user and as well as generates revenue for the provider. Hence SLA is required to have a clear understanding between CSP and the customer about the services.

Importance of SLA :

A SLA is essential for the following reasons.

1. Customer point of view :

Each CSP has its own SLA, If a customer wants to use a cloud service, customer can compare the SLA's of different organizations. This lets customer to compare and choose better SLA for his requirements.

2. CSP point of view :

In some cases, certain performance issues may occur for a particular service, because of which a CSP may not be able to provide the services efficiently. So in such cases, CSP can explicitly mention in the SLA that they are not responsible for inefficient service.

Metrics of SLA

The following are the common metrics required for construction of SLA :

1. Availability :

This metric signifies the amount of time the service will be accesible for the customer.

2. Response Time :

Response Time is the maximum time taken to respond for a customer request.

3. Portability :

This metric indicates the flexibility of transfering the data to another sevice.

4. Problem reporting :

This metric explains how to report a problem, whom and how to contact.

5. Penalty :

The Penalty for not meeting the promises mentioned in the SLA.

Cloud Implementation

The requirement for cloud computing is rapidly increasing with the deployment of IOT infrastructure for different applications.

The Real deployment of the cloud is a complex and costly procedure.

Thus there is a requirement for simulating the system through a simulator before real implementation.

Cloud simulation

Cloud simulators provides pre-deployment test services for performance evaluation of a system. A cloud simulator has the following advantages to a customer :

* Pre-deployment test before real implementation.
* system testing at no cost.
* pre-detection of issues.
* Repeated evaluation of the system.
* Flexibility to control the environment.

Few Cloud simulators include CloudSim, CloudAnalyst GreenCloud.

(i) CloudSim : Description

* This was developed at the university of Melbourne.
* This is Java-based.
* Features :

1. This provides Various cloud Computing data Centers in simulation environment.
2. this allows Virtualization of server hosts.
3. This allows users to define their own policies

for the allocation of host resources to VMs.

4. This provides flexibility to add or remove simulation components dynamically.

5. A user can stop and resume the simulation at any instant of time.

(ii) CloudAnalyst :

Description :

This is based on Cloudsim.

This simulator provides a graphical user interface (GUI) for simulating a cloud environment easily.

This is used for simulating large-scale cloud applications.

Features :

* This is easy to use due to the presence of GUI.
* This allows the user to add components and provides a flexible and high level of configuration.
* A user can perform repeated experiments, considering different parameter values.

* 4. It can provide a graphical output, including a chart and table.

(iii) GreenCloud

Description :

GreenCloud is developed as an extension of a packet level network simulator, NS2.

Features :

* GreenCloud is an open-source simulator with user-friendly GUI.
* This provides the facility for monitoring the energy consumption of network and various components.
* this supports simulation of cloud network components.
* This enables power management schemes.
* This enables monitoring energy consumption of network components such as servers and switches.

OpenStack - An Open source cloud

There are various open-source cloud platforms available for the real implementation of cloud. Few open source cloud are OpenStack, Cloudstack and Eucalyptus.

The OpenStack is free software, which provides cloud IaaS to users.

Features of OpenStack

* This can be used with the help of GUI based web interface or through the command line.
* This consists of vast pre-configured software suites.
* allows to create and deploy virtual machines.
* This also provides the flexibility of setting up a cloud management environment.
* This supports easy scaling : dynamic addition & removal of instances.
* This allows access to the source code and share their code to the community.

Amazon web services (AWS) : A Commercial cloud

* AWS is one of the commercial cloud infrastructures.
* AWS provides different APIs (Application Programming instances), tools and utilities for users.
* This follows pay-per-use model.
* This cloud infrastructure provides a virtual computing environment, different configurations such as CPU, memory, storage and networking capacity are available.

features of AWS :

1. This follows pay-per-use model.
2. This allows user to establish connectivity between the physical network and private virtual network.
3. AWS has excellent management tools.
4. this provides machine learning facilities, which are useful for data scientists and developers.
5. AWS provides flexibility to scale and manage the server capacity.
6. AWS provides excellent developer tools.

Few of the other Commercial cloud infrastructures are Microsoft azure and Google App trgine.

Sensor - cloud : Sensors - as - a - service

* In Sensor cloud architecture, Virtualization of sensors plays an eventual role.
* this provides services to multiple users.
* Multiple users recieves services from different sensor nodes
* This also follows the pay-per-use model.

Importance of Sensor-cloud

* A User application is served by a set of homogeneous or heterogeneous sensor nodes.
* There sensor nodes are selected from a common pool of sensor nodes as per the user requirements.
* this restricts from pre-deployment and post deployment hurdles.

Advantages of sensor cloud over traditional Wireless sensor networks

* In WSN, one has to decide the sensors for example A farmer has planned to deploy

a WSN in farming field for supervision of the entire field. He has to decide the types of sensors, for sensing different agricultural parameters.

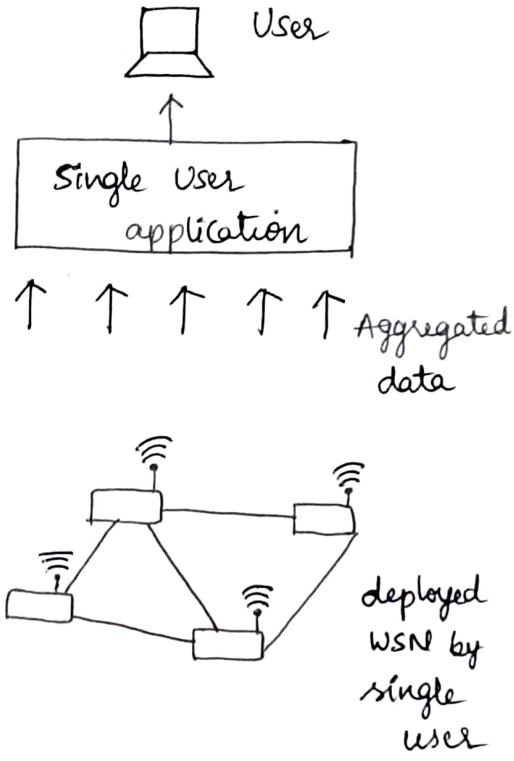
He also has to decide the type and number of other electronics circuit board and communicate module along with sensors.

Hence Traditional WSN need maintainance, deployment & hardware management regularly.

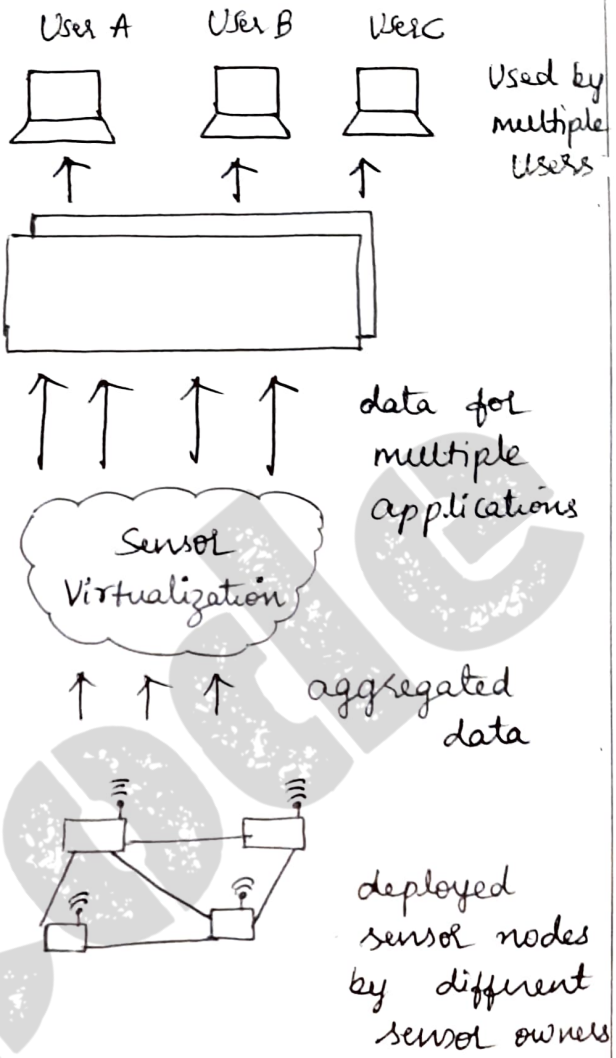
But using sensor-cloud architecture, this WSN can be used on a rental basis and doesnot have to bother about the maintainance and all.

Afterwards its also easy to switch the application without any manual intervention using sensor cloud.

Sensor service providers of sensor cloud infrastructure also serves multiple users with the same sensors and earns profit.



Traditional WSNs



Sensor cloud

Traditional WSN Versus Sensor cloud

Architecture of Sensor cloud platform

In Sensor cloud architecture, three actors play a important role : End user, sensor owner and sensor-cloud service provider (SCSP)

(1) End-User :

There are the Customers of the sensor cloud services.

* An End user registers himself with the infrastructure through a web portal.
* The end user recieves the services through the web portal.
* End user can choose the template of the services that are available in the sensor cloud architecture.
* End user pays charges to SCSP based on the type and usage duration of service.

(ii) Sensor owner :

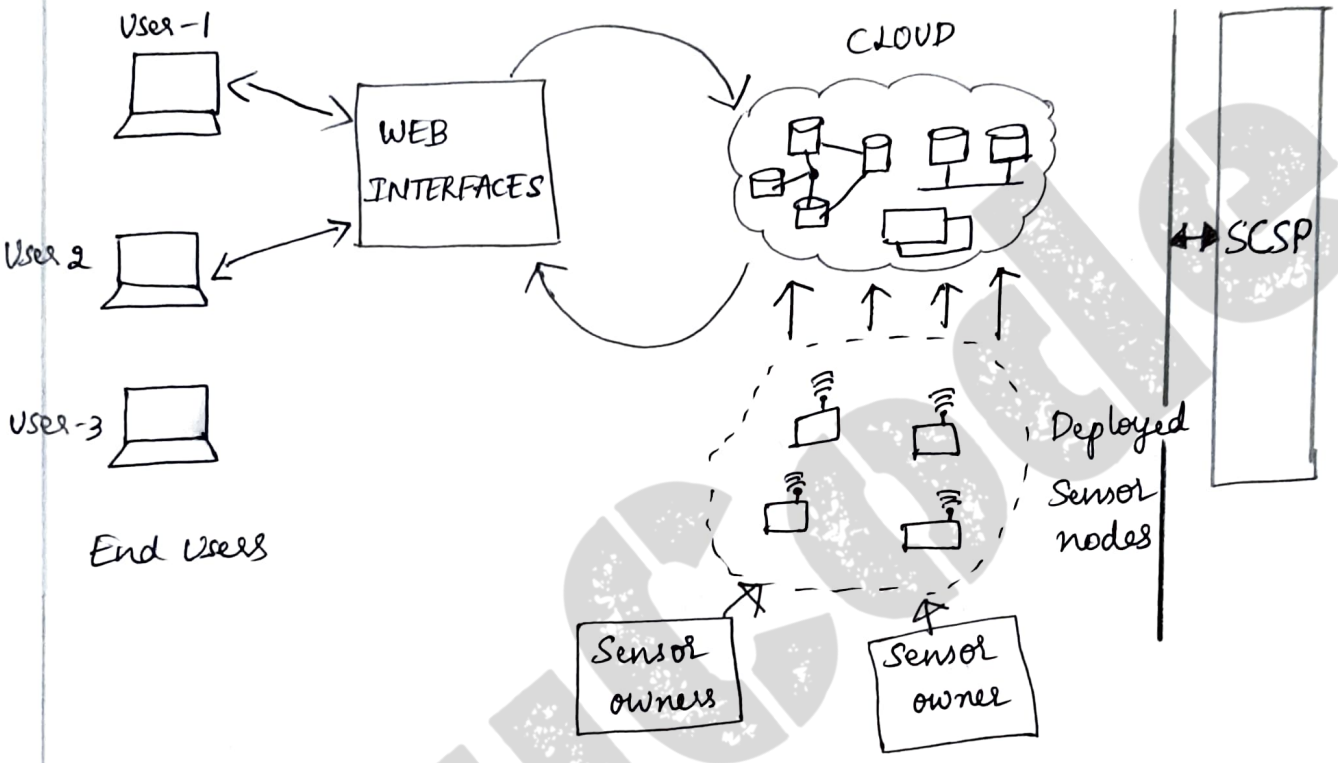
* The sensors are owned and deployed by the sensor owners.
* A sensor owner can own multiple homogeneous or heterogeneous sensor nodes.
* the sensors are virtualized and assigned to multiple applications based on the requirements.
* Sensor recieves rent depending upon the duration and usage of sensor node.

(iii) Sensor-cloud Service Provider (SCSP)

* SCSP is responsible for management of sensor owners and end users ; resource handling, database management and cloud handling.
* Algorithms are used for managing the entire infrastructure.
* SCSP recieves rent from end users with the help of

predefined pricing model.

* The pricing scheme includes the infrastructure cost, sensor owner's rent and the revenue of SCSP.



Architecture of a Sensor-cloud platform

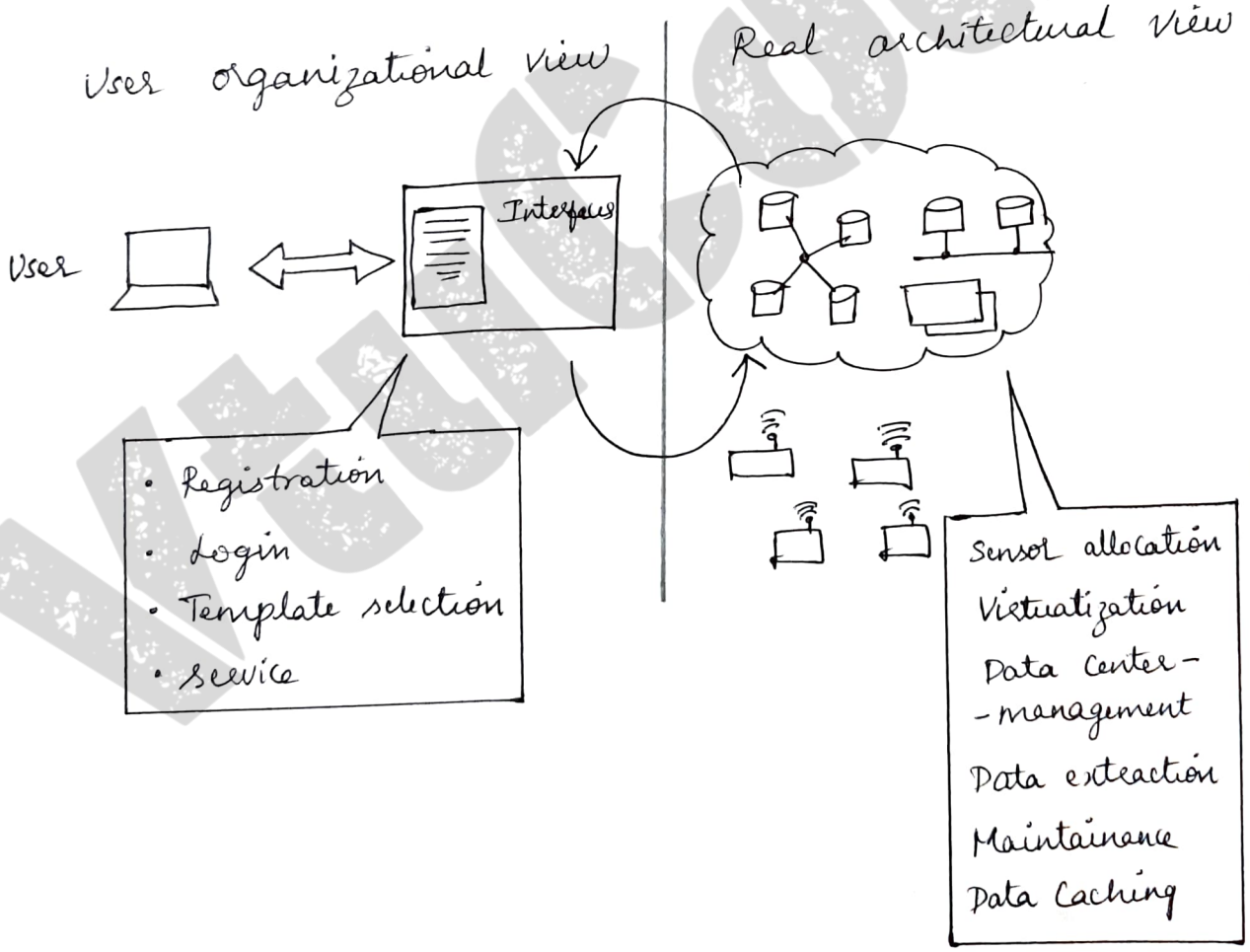
Sensor cloud architecture from different viewpoints

(i) User organizational View :

* This view of sensor cloud architecture is simple.
* In this, an end users interacts with a web interface for selecting templates of the services.
* An end user is unaware of the complex process that are running at the back end.

ii) Real Architectural View :

* The complex procesing of sensor cloud architecture is visualized through this view.
* The process include sensor allocation, data extraction from the sensors, Visualization of sensor nodes, maintainance of the infrastructure, data center management, data caching and others.
* there is a specific algorithm for each proces or scheme.



Sensor cloud architecture different views